Predictive maintenance tips for electric motors

Vibration monitoring, electrical testing and visual inspections can help keep electrical motors humming along

Electric motors are the most common source of motive power for machine trains. An effective predictive maintenance (PdM) program for them must include a combination of vibration monitoring, electrical testing and visual inspections.

Vibration monitoring

The vibration frequencies of the following parameters are monitored to evaluate operating condition. This information is used to establish a database.

Bearing frequencies.

Electric motors use either sleeve or rolling-element bearings. Establish a narrowband window to monitor both normal rotational and defect frequencies associated with each bearing type.

Imbalance. Electric motors are susceptible to a variety of forcing functions that cause instability or imbalance. While the narrowbands are useful in identifying mechanical imbalance, other indices also should be used.

One such index is line frequency, which provides indications of instability. Modulations, or harmonics, of line frequency may indicate the motor's inability to find and hold magnetic center. In-line frequency variations also increase the amplitude of the fundamental and other harmonics of running speed.

Axial movement and the resulting presence of a third harmonic of the running speed is another indication of motor instability or imbalance. The third harmonic is present whenever there is axial thrusting of a rotating element.

Line frequency. Many electrical problems, including those associated with the quality of the incoming power and internal to the motor, can be isolated by monitoring the line frequency. It refers to the frequency of the alternating current being supplied to the motor. In the case of 60-cycle power, monitor the fundamental or first harmonic (60 Hz), second harmonic (120 Hz), and third harmonic (180 Hz).

Loose rotor bars. This is a common failure mode of electric motors. Two methods can detect them.

The first uses the high-frequency vibration components caused by the oscillating rotor bars. These frequencies are well above the normal maximum frequency used to establish a broadband signature. If this is the case, a high-pass filter, such as high-frequency domain, can be used to monitor the rotor bar condition.

The second uses the slip frequency to identify loose rotor bars. The passing frequency created by this failure mode energizes modulations associated with slip. This method is preferred because these frequency components are within the normal bandwidth used for vibration analysis.

Running speed. The running speed of electric motors, both AC and DC, varies. For monitoring purposes, these motors are classified as variable-speed machines. Establish a narrowband window to track true running speed.

Slip frequency. This is the difference between synchronous speed and the motor's actual running speed. Establish a narrowband filter to monitor line frequency. The window needs enough resolution to identify clearly the frequency and the modulations, or the sidebands that represent slip frequency. Normally, these modulations are spaced at the difference between synchronous and actual speed; the number of sidebands is equal to the number of poles in the motor.

V-belt intermediate drives. Electric motors with these drives display the same failure modes as those described previously. However, monitor the V-belts' unique frequencies to determine if improper belt tension or misalignment is evident. In addition, electric motors with V-belt intermediate drive assemblies are susceptible to premature bearing wear.

The primary data-measurement point on the inboard bearing housing should be located in the plane opposing the induced load (sideload), with the secondary point at 90 degrees. The outboard primary data-measurement point should be in a plane opposite the inboard bearing with the secondary at 90 degrees.

Electrical testing

Traditional electrical testing methods must be used in conjunction with vibration analysis to prevent premature failure of electric motors. These tests should include resistance, megger, HiPot and impedance testing.

Resistance testing. Resistance is measured by using an ohmmeter. In reality, it does not measure resistance directly, but measures current instead. The meter is calibrated in ohms and its movement reflects the current. The amount of current supplied by the meter is very low, typically in the range of 20 to 50 microamperes. The meter functions by applying its terminal voltage to the test subject and measuring the circuit current.

For practical purposes, while resistance testing is of limited value, there are some useful tests that can be performed. A resistance test will indicate an open or closed circuit. This can tell us whether there is a break in a circuit or if there is a dead short to ground.

It's important to keep in mind that inductive and capacitive elements in the circuit distort resistance measurements. Capacitive elements appear initially as a short circuit and begin to open as they charge. They appear as open circuits when they are fully charged. Meanwhile, inductive elements appear initially as open circuits and the resistance decreases as they charge. In both cases, the charging time is tied to the circuit's resistance, capacitance and inductance. It still requires five time constants to charge capacitors and inductors. It is also important to remember that when disconnecting the meter from the circuit, the capacitive and inductive elements are charged. Observe due caution when disconnecting test equipment.

Resistance testing coils is of limited value. It will detect an open coil or one shorted to ground, but it often will not detect shortened windings or weak insulation.

Megger testing. To measure very high resistances, a megohmmeter can be used. Unlike a normal ohmmeter, it measures voltage instead of measuring current to determine resistance.

This testing mode involves applying high voltage (500 to 2,500 volts, depending on the unit) to the circuit to verify there's no insulation breakdown. Generally, this is considered a non-destructive test, depending on the applied voltage and the insulation rating. A Megger is used primarily to test the integrity of insulation.

HiPot (high potential) testing. This potentially destructive test determines the integrity of insulation. Voltage levels used with this test are twice the rated voltage, plus 1,000 volts. Some equipment manufacturers and rebuilding facilities use the test as a quality assurance tool. It's important to note that HiPot testing does some damage to insulation every time it is performed. Because it can destroy insulation that is still serviceable, it's generally not recommended for field use.

Impedance testing. Impedance has two components: real (or resistive) and reactive (inductive or capacitive). This test can detect significant shorting in coils, either between turns or to ground. No other non-intrusive method is capable of detecting a coil that is shorted between turns.

Visual and aural inspections

A great deal can be learned about the condition of a motor just by looking at it. Here are some things to look for and how they relate to motor condition monitoring.

Dust and dirt in and around motors can cause several problems. When stuck to rotors and cooling fans, dust and dirt add weight and can cause balance problems. They also obstruct cooling airflow and provide a thermal insulation for parts that should be cooled. Dust and dirt found in and around electric motors is composed primarily of silicon (highly abrasive) and carbon (reasonable conductor of electricity). Both can puncture insulation and increase the probability of a short circuit.

Insufficient lubrication can damage bearings and cause overheating and greatly accelerate wear. Overlubricating can cause overheating, increased vibration and seal damage. Leaked lubricant is an excellent dirt magnet, resulting in both accumulation and contamination. Increased vibration shortens bearing life.

High operating temperatures also decrease bearing life. Excessive heat also breaks down insulation. Units running abnormally hot are usually not difficult to identify.

Excessive noise may indicate a mechanical or electrical problem. Usually, there is substantial vibration levels present in noisy motors.

Visual inspection of DC motors may be done while the unit is in operation. For example, some motors and generators have exposed brush/commutators/armature components.

Brushes. Brush condition can be evaluated visually. Replace those that appear worn, chipped or binding in their holders. In addition, look for damage to shunts, connections and clips. No brush should be worn to within 1/8 in. of any metallic part. Brush toes should be aligned parallel to commutator grooves. Any excessive arcing or sparking damages brushes, so they should be replaced.

Tamped connections without hammer springs and spring-enclosed shunts should not be worn to less than half the original length. Brush holders should be the same distance from the commutator, between 1/16 and 1/8 in.

Commutators. The surface of a commutator should be a uniform, glazed and dark brown in color. If the color is non-uniform or bluish, improper commutation conditions exist. Commutator slots also should be free of debris buildup. High mica or feather-edged mica may cause sparking, streaking or threading.

The commutator surface should be concentric with the rotor centerline within 3 mils. Any visible radial brush movement should be corrected as soon as possible.

Armatures. Excessive heat and burnt odors indicate burned insulation. Charred insulation may indicate a shorted coil.

Other armature electrical defects are open and grounded coils. An open coil is indicated on a running motor by a bright spark, which appears to pass completely around the commutator. A grounded armature coil will cause a ground test lamp to flicker when the coil passes brushes. A megger test can validate the existence of these conditions.

Final notes

Because electric motors are critical machine-train components, an effective PdM program must include the proper techniques to monitor their operating condition. While the previous discussed techniques provide a basic program, other techniques, such as thermography, also can be used.

One final suggestion: Always remember that electric motors are designed to seek and operate at their true magnetic center. When coupled to a driven unit, either by a coupling or a flexible drive, the motor's operating dynamics are controlled directly by the driven unit's operating condition. Instability in the process or driven unit directly affects the condition of the motor.

Reference:

http://www.plantservices.com/Web_First/ps.nsf/ArticleID/HCOK-53TT6H?OpenDocument&Click=